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THE COLLECTING AREA OF THE WATERS OF THE HOT SPRINGS, HOT SPRINGS, ARKANSAS¹

A. H. PURDUE

University of Arkansas, Fayetteville, Ark.

Introduction.—The unusual interest with which the hot springs of Arkansas are regarded because of their temperature and their renown for medicinal purposes, furnishes the reason for the somewhat exhaustive consideration of the source of their waters, which follows. The conclusions herein presented were reached in the course of field work on the structure and stratigraphy of the area about Hot Springs, during the summer of 1909. The paper is written with the assumption that the waters of the hot springs are meteoric. This assumption is made partly because geologists in general have come to think of most of the ground-water as having such origin, and partly because the recent studies of Mr. Walter Harvey Weed upon the waters of these springs indicate that they are meteoric.²

General topographic relations of the hot springs.—In casting about for all possible sources of the waters of the hot springs, the highlands of Arkansas and Oklahoma and those of the Appalachian province command attention.

The highlands of Arkansas and the eastern part of Oklahoma are divided into a northern and a southern part, separated by the valley of the Arkansas River. The northern division consists of the Boston Mountains, which are a dissected plateau, reaching the height of somewhat more than 2,200 feet above sea-level, and a much lower area to the north of them. The southern division consists of the Ouachita Mountains, which cover an area about 50 miles wide and 200 miles long. These mountains consist of ridges, the direction of which is in the main east and west and some of which surpass 2,000 feet in height.

¹ By permission of the Chief Geologist, U.S. Geological Survey.

² "The Hot Springs of Arkansas," *Senate Doc. No. 282*, p. 90, Washington, D.C., 1902. Prepared under the supervision of the Secretary of the Interior.

In the Appalachian province, the Cumberland Plateau exceeds 2,000 feet and the Appalachian Mountains 6,000 feet in height.

Topography of the area about the hot springs.—The topography in the vicinity of the hot springs is shown by the accompanying relief map (Fig. 1). The springs, indicated by the cross, emerge from the western end of Hot Springs Mountain, which is known as Indian

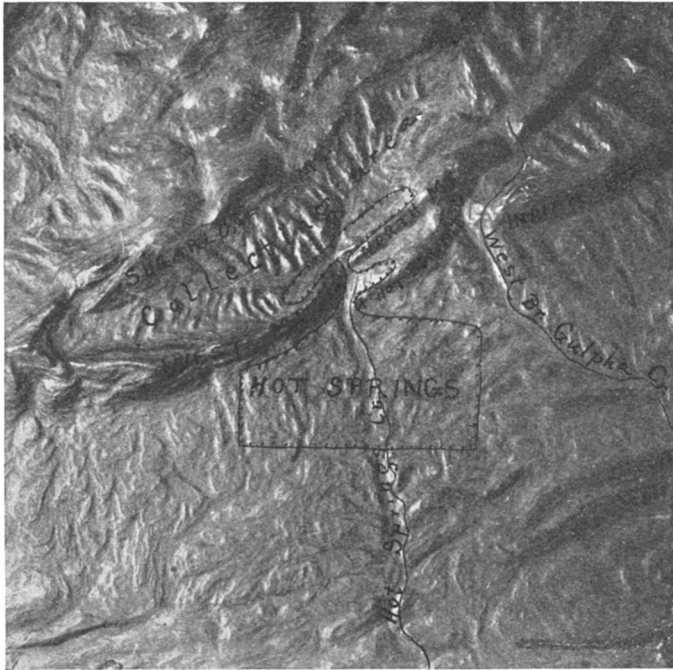


FIG. 1.—Relief map of the Hot Springs area

Mountain east of West Branch of Gulpha Creek. Immediately north of Hot Springs Mountain is North Mountain, which continues west of Hot Springs Creek, as West Mountain. Three miles west of the springs, West Mountain swings around in a horseshoe curve and extends northeastward, and is known as Sugarloaf Mountain. Hot Springs Creek, a considerable stream, flowing southward, carries off the overflow from the hot springs and the drainage of a portion of the valley just south of Sugarloaf Mountain.

This valley is from a mile to a mile and a quarter in width. About two miles northeast of the hot springs where West Branch of Gulpha Creek cuts through North Mountain, there is a limited area with an elevation of 620 feet. The greater part of the surface, however, stands above the 700-foot contour, and the highest hills exceed 800 feet. The highest elevation at which any of the springs emerge is 640 feet.

Structure and rocks of the highland areas.—The general structure of the highland area is that of a broad syncline with its trough in the Arkansas Valley. The rocks are sandstone, limestone, and shale. Those of the Boston Mountains and the area to their north lie for the most part horizontal, but in the south half of the Boston Mountains they dip perceptibly to the south, and in the Arkansas Valley pass under several thousand feet of younger rocks.

The general structure of the Ouachita area is that of an anticlinorium dipping southward under the Mesozoic and Tertiary rocks and northward beneath those of the Arkansas Valley. The rocks are intensely folded, to which, with erosion, is due the narrow valleys and parallel ridges of the area. The folds in the main have an east-west direction, but at Hot Springs and for some distance to the west, their direction is northeast-southwest. The individual folds are not continuous for great distances, but are short and overlap each other laterally. Thrust faults, approximately parallel to the strike, and of many hundred feet displacement, occur in the Ouachita Mountains and the Arkansas Valley. The hot springs are located in the eastern part of the Ouachita area.

The stratified rocks of the Appalachian province are sandstone, limestone, and shale. Their continuity is broken by faulting, and the rocks of the Cumberland Plateau dip away from the Cincinnati arch toward the southeast. The rocks west of the Cincinnati arch are practically horizontal, and are truncated along the Embayment border. Against their truncated edges, the later rocks of the Embayment area rest unconformably.

Structure and rocks of the area about the hot springs.—Like the remainder of the Ouachita region, the area about the hot springs is intensely folded. The folds are closely compressed and all are overturned to the south. As a result, the dips are to the north. Some

of these are as low as 15 degrees and they seldom exceed 60 degrees. This means that, at the points of greatest overturning, the rock layers lie literally upside down, and, in folding, have described an arc of 165 degrees.

The surface rocks about the hot springs are shown in the following section:¹

		Feet
Carboniferous	{ Stanley shale.....	3,500
	{ Hot Springs sandstone.....	100
Age unknown	{ Arkansas novaculite.....	380
	{ Missouri Mountain slate.....	50
Ordovician...	{ Polk Creek shale.....	210
	{ Bigfork chert.....	570

The Bigfork chert is in layers from two to twelve inches thick. Throughout most of the formation, it consists almost entirely of chert, but in parts the layers are separated by thin beds of shale, and in other parts shale is the main constituent. The chert is very brittle and is intensely fractured from the folding it has suffered.

The Polk Creek shale overlies the Bigfork chert, and is a very black, somewhat siliceous shale, though soft enough from its graphitic nature to soil the fingers in handling. The upper part contains a few thin, siliceous beds, but the lower part is wholly shale.

The Missouri Mountain slate, as it occurs in the vicinity of the hot springs, is a red to brown or yellow shale, depending upon the stage of weathering. Further west in the Ouachita area, it is a true slate.

The Arkansas novaculite, as it is exposed in the vicinity of the hot springs, consists of three parts: A lower, massive one 275 feet thick, made up of heavy beds of much fractured novaculite. It is from this part of the formation that the Arkansas abrasives are secured. This is followed by fifty-five feet of very black clay shale, weathering in places to light gray; and this by fifty feet of what appears to be rotten, porous novaculite. The section of the novaculite formation over the Ouachita area varies greatly with the locality.

The Hot Springs sandstone² is a gray, quartzitic sandstone, in

¹ With the exception of the Stanley shale and the Hot Springs sandstone, these names were first applied to the formations as they appear in Montgomery County, Arkansas.

² This name has not been used before in Arkansas.

beds from three to eight feet thick. The basal ten feet is conglomeratic. It is from this formation that most of the hot springs issue, which fact, however, is not significant.

The Stanley shale is composed mainly of black to green clay shale, though a large percentage of it consists of rather soft, greenish sandstone. This shale skirts Hot Springs and West Mountains. While a large part of the city of Hot Springs stands on this formation, only the waters of those springs that issue at the lowest levels move through it.

Possibilities of ground-water flowage.—While the altitude of the Boston Mountains is sufficient to give the ground-water enough head for it to emerge at the height and distance of the hot springs, the intervening structure makes such impossible. The closely compressed folds, their lateral overlapping, and the faulting of the Ouachita area

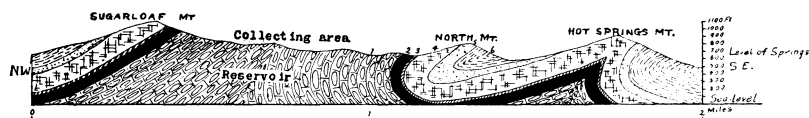


FIG. 2.—Northwest-southeast section at Hot Springs. 1. Bigfork chert. 2. Polk Creek shale. 3. Missouri Mountain slate. 4. Arkansas novaculite. 5. Hot Springs sandstone. 6. Stanley shale.

to the north and west of the hot springs are such as to prevent the uninterrupted movement of ground-water except for short distances. Likewise the stratigraphy, structure, and topography to their south eliminate that area as a possible source of the water; and the structure of the Appalachian province and the Embayment area is such as to preclude the former as a possible location of the water head.

The collecting area.—It follows from the above that the collecting area must be in the near vicinity of the springs, and a study of the topography, stratigraphy, and structure thereabout locates it with reasonable certainty. A glance at the section (Fig. 2) from Sugarloaf Mountain southeastward through Hot Springs Mountain will indicate the collecting area. The surface of the overturned, anticlinal valley between Sugarloaf and North mountains is higher than the level of emergence of the springs. The rocks outcropping over the area are the Bigfork chert and the Polk Creek shale, the former occupying most of the area.

The considerable thickness of the Bigfork chert, its much fractured nature, and the thin layers of which it is composed, all combine to make it a water-bearing formation of unusual importance. The greater number of the fine springs in the Ouachita area between Hot Springs and the western border of the state come from this horizon. In many places this formation occurs in anticlinal valleys with its highly inclined beds truncated, affording the most favorable condition for the intake of water. A glance at Fig. 2 will show that these conditions obtain in the area between North Mountain and Sugarloaf Mountain. In addition to the favorable structure for the reception of water, there is the stratigraphic condition for its retention brought about by the overlying Polk Creek shale. As a consequence of the topography, structure, and stratigraphy, the water is collected in the basin shown in the map (Fig. 1), conducted through the Bigfork chert

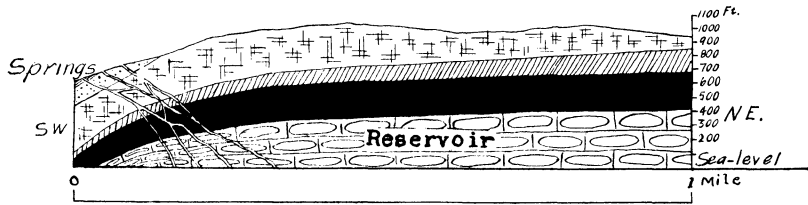


FIG. 3.—Northeast-southwest (longitudinal) section of Hot Springs Mountain, showing the hypothetical water conduits at the plunging end of the anticline. Symbols, same as in Fig. 2.

beneath the North Mountain syncline, and forced up into the Hot Springs anticline, at the western end of which it emerges in the hot springs. Including several of weak flow, there are said to be seventy-two of these springs, and they are confined to a narrow strip about a quarter of a mile long.

The exact location of the springs is attributable to the southwestern plunge of the Hot Springs anticline, and as has been stated by Mr. Walter Harvey Weed¹ probably to fracturing and possibly slight faulting in the process of folding, as shown in Fig. 3.

While not relevant to the title of this paper, it might be added that the considerable number of dikes in the vicinity of the hot springs, the large number (eighty are known) only four miles to the southeast,

¹ *Loc. cit.*

on and near the Ouachita River, and the areas of igneous rock at Potash Sulphur Spring, Magnet Cove, and other near places, force the suggestion upon one that the waters of the springs owe their temperature to passing over hot rocks, or the vapor from such, in some part of their underground course. The fact that these are practically¹ the only hot springs within the Ouachita area, though there are scores of cold springs issuing from the same formations and under the same geologic relations, gives this suggestion great weight; but inasmuch as some of the hot springs are said to be unusually radioactive, there is the alternative suggestion that atomic decomposition in igneous rocks (which may have lost their magmatic heat) is the source of the high temperature of the water.

¹ Recently a spring, said to have a temperature of 98° to 100° F., has been discovered issuing from the Arkansas novaculite in the bed of the Caddo River at Caddo Gap, Montgomery County.